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A Review of the Performance of AFFF Systems Serving Helicopter Decks on U.S. Navy Surface Combatants

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The AFFF systems serving the helo decks on surface combatants are designed for rapid control and extinguishment of JP-5 pool fires. Based on the available data, *either* the flush deck system at an application rate of 0.06 GPM/SqFt or a single hose line at 125 GPM would be expected to perform as follows against a pool fire engulfing the landing area of the CG-47, DD-963, FFG-7, or DDG-51:

Fire Control Time: 30 s
Fire Extinguishment Time: 60 s

This estimate assumes a typical wind of 15-30 kts in a general fore-to-aft direction. Extreme wind conditions outside the normal range could add 15-30 s to the above times. This estimate also assumes that the AFFF systems are adequately maintained and operationally ready and that flight quarters personnel are properly trained.

A simultaneous attack by both systems could facilitate even more rapid fire control.

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CONTENTS

A REVIEW OF THE PERFORMANCE OF AFFF SYSTEMS SERVING HELICOPTER DECKS ON U.S. NAVY SURFACE COMBATANTS

INTRODUCTION

The Navy experienced two disastrous conflagrations on aircraft carrier flight decks in the late 1960s (Forrestal in July 1967 and Enterprise in January 1969). One of the primary Lessons Learned from these incidents was the need to upgrade fire fighting capability on flight decks. Enhanced fire fighting was achieved by the installation of AFFF systems on all carrier flight decks in the 1970s. In the 1980s, the concept was extended to flight decks of other large aviation ships and ultimately to helo decks on frigates, destroyers and cruisers. Numerous large-scale fire tests were conducted to establish the design parameters for these systems.

During the period 14-16 September 1999, the CNO Surface Ship Aviation Working Group met in Norfolk, VA. The purpose of the meeting was to evaluate potential manpower reductions in support of flight quarters on combatant ships. The possibility of relaxing the minimum number of personnel assigned to helo deck hose teams was one of the items under discussion. During deliberations on this issue, it became apparent that fleet personnel were unaware of the capability of the existing AFFF systems installed on helo decks. It was concluded that a better understanding of the performance parameters of AFFF was necessary in order to reach a consensus on any change in hose team manning.

OBJECTIVE

The objectives of this paper are twofold:

1. Review historical test data applicable to AFFF systems on helo decks aboard surface combatants (specifically DDG-51, CG-47, DD-963, and FFG-7 class ships), and

2. Quantify the fire fighting performance of those systems

AFFF SYSTEMS ON HELO DECKS

The standard AFFF fire fighting system on helo decks consists of flush deck nozzles and hose lines.

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The flush deck nozzles are the same nozzles utilized for NBC washdown on ship exterior deck surfaces. For helo decks, the nozzles serve a dual role (washdown and fire fighting). When used for fire fighting, AFFF solution is discharged from the nozzles over the entire helo deck. The nozzles are installed with a nominal coverage of 500 sq ft per nozzle. Each nozzle flows a minimum of 30 gpm, providing an overall application rate on the helo deck of 0.06 gpm per sq ft of deck area. The system is activated from the helo control station and is designed to provide full flow within a few seconds from when the button is pushed. The intent of the flush deck system is to rapidly control a fuel fire on the deck to facilitate rescue of helo occupants and to prevent cook-off of helo-carried ordnance.

A minimum of two AFFF 1 ½ inch hose lines are also provided immediately forward of the landing area. The hose is of the non-collapsible type and is installed on a flow-thru reel. Unlike soft hose on racks, the reel is specifically designed for immediate deployment by one person since only the amount of hose actually needed has to be unreeled. Each hose is equipped with an AFFF vari-nozzle rated to flow 125 gpm. The AFFF proportioning station supplying each reel is activated from an electric push button adjacent to the reel.

AFFF used on Navy ships is procured to a stringent specification (Mil-F-24385) governing the fire fighting performance of the agent. The performance of foam fire fighting agents is typically expressed as a function of the required foam solution application rate over a given fuel fire area. This performance parameter is frequently referred to as application density (the gallons of foam solution required per square foot of fire area). The relationship between application rate, extinguishment time and application density is governed by the following equation:

Application Rate x Time = Application Density

Gallons/minute/square foot x minutes = Gallons/square foot

In order to pass the fire performance requirements of the Mil Spec, an AFFF must extinguish a gasoline pool fire at an application density of 0.033 Gals/SqFt. To achieve this, a gasoline pool fire must be extinguished within 50 seconds at an overall application rate of 0.04 GPM/SqFt. Gasoline is specifically used in the mil spec test to provide an additional margin of safety, since gasoline is more difficult to extinguish than JP-5, the standard Navy aviation fuel. By designing the flush deck system to have a minimum application rate over the landing area of 0.06 GPM/SqFt, a design objective was established to control a helo deck pool fire in less than 60 seconds.

SUMMARY OF TESTING

Since the FORRESTAL conflagration in 1967, numerous test programs involving over a thousand tests have been conducted to develop and refine AFFF systems and equipment for flight deck applications. Most testing was done on a simulated flight deck at the Naval Air Warfare Center, China Lake, CA. Original AFFF flight deck testing was conducted at NAS Jacksonville and many smaller scale tests have been run at the Naval Research Laboratory(NRL) (Chesapeake

Bay Detachment). Many of these tests were not particularly applicable to helo decks as they involved proposed systems for aircraft carriers such as deck edge nozzles, large capacity monitors, vehicles, robots, high flow flush deck nozzles and alternative agents. However, an exhaustive search of all available test data, both published and unpublished, has identified approximately 35 Navy tests, encompassing 8 different test programs, over the 25 year period from 1968 to 1992, that are representative of AFFF systems installed on surface combatants (specifically AFFF flush deck and hose lines). These are in addition to the AFFF mil spec qualification tests, which are routinely run at NRL. The test series from which the data has been extracted are summarized below.

Jacksonville, December 1968(1)

This was the original test series involving seawater compatible AFFF. A total of 36 tests were run to confirm the efficacy of using AFFF on aircraft carriers. Of these, three tests run with AFFF hose lines are considered indicative of helo deck AFFF hose line performance. Detailed results are reported under "Specific Test Data" below.

NWC China Lake, Phase I, February/March 1970(2)

A series of 26 tests were conducted on a simulated flight deck to refine the proposed design for aircraft carrier AFFF systems. Two AFFF flush deck tests were directly relevant to the flush deck design on surface helo decks.

NWC China Lake, Phase II, November 1970(3)

This series was a continuation of the Phase I China Lake tests involving various proposed AFFF systems evaluated under varying wind conditions. Seven of the twelve tests involved AFFF flush deck and /or hose lines and are considered applicable to the performance of current systems on helo decks.

NWC China Lake, Phase III, February 1972(4)

Phase III of the original China Lake Mini-Deck series evaluated the performance of AFFF against aviation gasoline. These tests were necessitated by the Navy's decision to extend the life of the S-2 aircraft, which were fueled by aviation gasoline vice JP-5. Two baseline AFFF flush deck tests and two hose line tests are considered to be applicable to helo deck AFFF system performance.

NWC China Lake, October 1982-November 1983(5)

This multi-series test program is commonly referred to as the "Nimitz Report" since it evolved from the 1981 flight deck fire aboard the USS Nimitz, in which fire parties were hampered by a lack of upwind access and aircraft debris. Four flush deck system tests involved the same design as the flush deck nozzles found on helo decks. Two hose line tests were run with 125 gpm vari-nozzles, same as on helo decks.

NRL Chesapeake Beach, 1984(6)

In this series, a total of 45 tests were conducted to evaluate two prototype flight deck firefighting robots, the "Fire Cat" and the "Fire Fox". Two of the tests involved an AFFF hose line against a debris pile. The AFFF hose line results are considered applicable to the helo deck scenario.

NWC China Lake, December 1984-February 1985(7)

This test series was conducted to evaluate a prototype pop-up nozzle as a possible replacement for the standard flush deck nozzle. Three baseline tests with AFFF flush deck nozzles involved the same application rate as on current helo decks.

NRL Chesapeake Beach, 1991(8)

This test series was undertaken to quantify the projected impact of a proposed conversion to JP-8 aviation fuel. An assessment of AFFF hose line performance against debris pile fires is applicable to helo deck hose lines.

SPECIFIC TEST DATA

Actual recorded data considered germane to the performance of helo deck AFFF systems has been extracted from the references cited above, and is presented below. Shown for each test are the "test conditions" and the fire fighting performance of the system involved. The test conditions include a description of the AFFF delivery method (flush deck and/or hose lines), fire threat (fuel quantity and fire size) and pertinent factors that influence the speed of extinguishment.

Wind is an important factor. The AFFF flush deck system performs better with wind over the deck because the wind helps to rapidly distribute the agent over the fuel surface. Nozzles immediately upwind of the fire are major contributors to rapid fire control. On the other hand, wind can have an adverse affect on hose line operations, especially where an attack would have to be made against the wind. It is for this reason that AFFF hose reels on helo decks are mounted forward of the landing area. Obstructions on the deck can shield the rapid distribution of the AFFF solution from the flush deck nozzles. Wind was generated during the test programs by using either the prop wash from an aircraft or airboats with engine-powered fans. Running or dripping fuel can slow down extinguishment and present a continuous reignition source. To

simulate obstructions, running fuel and re-ignition sources that might accompany an aircraft crash, most of the cited tests involved one or more of the following: an iron mock-up of an aircraft fuselage or actual aircraft parked in the center of the fire, a fuel drum, piles of tires, a debris pile and, in a few cases, ignited magnesium parachute flares and a fuel dump tank. The aircraft mock-up used in the China Lake tests was 36 feet in length and 6 feet in diameter. During most tests, fuel was piped into the mock-up and dripped from holes drilled in the bottom. The fuel drum was a 55 gallon drum with an open spigot, mounted on a stand. The debris pile was developed to simulate conditions encountered on the Nimitz fire: a fire shielded on all sides by debris, a top wing obstruction and a cascading fuel fire in the middle of the debris. The cascading fuel flow rate on the standard debris pile was approximately 50 gallons per minute. In some tests, MK-24 magnesium parachute flares were placed in the center of the pool fire. A fuel dump tank, which could pivot to drop 150 gallons of fuel on the deck, was used in a few cases to simulate the sudden rupture of an aircraft fuel tank.

The measure of effectiveness for system performance is indicated below as "control time", "extinguishment time" and as an "application density" derived from AFFF "application rate". Control time is the time (measured from the start of AFFF discharge) necessary to achieve extinguishment of at least 90 % of the original fire area. In most of the tests, the fire area was outlined by an earthen berm to confine the fuel. Even where the pool fire was rapidly extinguished, fuel would often wick out of the soil berm, creating small fires at the edges, which would have to be extinguished before the fire was declared "all out" (extinguishment time). Accordingly, control time is the best measure of the ability of AFFF to rapidly suppress pool fires. The application density, as previously defined, is the amount of AFFF solution, per unit area, required to achieve extinguishment.

Jacksonville, December 1968(1)

Test # 22
Test Conditions: 3525 Sq Ft Fire (67 Ft Diameter Pool), 1000 gals JP-5, No Wind, Clear deck
Single AFFF 1 ½ Inch Hose Line @ 60 GPM
Control Time: 32 Seconds
Extinguishment Time: 41 Seconds
Application Rate: 0.017 GPM/SqFt
Application Density: 0.012 Gals/SqFt

Test # 23
Test Conditions: Same as Test # 22 with 30 Knots Wind
Control Time: 46 Seconds
Extinguishment Time: 66 Seconds
Application Rate: 0.017 GPM/SqFt
Application Density: 0.019 Gals/SqFt

Test # 29
Test Conditions: Repeat of Test # 22
Control Time: 38 Seconds
Extinguishment Time: 48 Seconds
Application Rate: 0.017 GPM/SqFt
Application Density: 0.014 Gals/SqFt

NWC China Lake, Phase I, February/March 1970(2)

Test # 14
Test Conditions: 2200 SqFt Pool Fire Area, 750 gals JP-5, Aircraft Mock-Up in Center of Fire Area, 30 Knots
AFFF Flush Deck @ .06 GPM/SqFt
Control Time: 20 Seconds
Extinguishment Time: 30 Seconds
Application Rate: 0.06 GPM/SqFt
Application Density: 0.03 Gals/SqFt

Test # 21
Test Conditions: Same as Test # 14, Except AFFF Solution at Half Strength (3% vice 6%)
Control Time: 25 Seconds
Extinguishment Time: 40 Seconds
Application Rate: 0.06 GPM/SqFt
Application Density: 0.04 Gals/SqFt
Note: Statement on bottom of data sheet claims flush deck spray only about 3 Feet High

NWC China Lake, Phase II, November 1970(3)

Test # 1
Test Conditions: 7500 Sg Ft Pool Fire Area, 2500 Gals JP-5, Aircraft Mock-Up With Running Fuel, No Wind
AFFF Flush Deck @.04 GPM/SqFt
Control Time: 27 Seconds
Extinguishment Time: 35 Seconds
Application Rate: 0.04 GPM/SqFt
Application Density: 0.023 Gals/SqFt

Test # 2
Test Conditions: Same as Test # 1, Except 30 Knots Wind
Control Time: 20 Seconds
Extinguishment Time: 28 Seconds
Application Rate: 0.04 GPM/SqFt
Application Density: 0.019 Gals/SqFt

Test # 4
Test Conditions: Repeat of Test # 2
Control Time: 30 Seconds
Extinguishment Time: 38 Seconds
Application Rate: 0.04 GPM/SqFt
Application Density: 0.025 Gals/SqFt

Test # 6
Test Conditions: Same as Test # 2, Except No Flush Deck, AFFF Hose Lines Only (2 x 60 GPM)
Control Time: 33 Seconds
Extinguishment Time: 45 Seconds
Application Rate: 0.016 GPM/SqFt
Application Density: 0.012 Gals/SqFt
Note: Second Hose Line Deployed 5 Seconds After First One

Test # 7
Test Conditions: Same as Test #2, Except 5 Aircraft Fuselages Added, Second Running Fuel Source From 55 Gal Drum, 15 Knots Wind, AFFF Flush Deck @ .04 GPM/SqFt and AFFF Hose Lines (2 x 60 GPM)
Control Time: 37 Seconds (Hose Lines Deployed at this Time)
Extinguishment Time: 70 Seconds
Application Rate (first 37 seconds): 0.04 GPM/SqFt
Application Rate (after 37 seconds): 0.056 GPM/SqFt
Application Density: 0.065 Gals/SqFt

Test # 8
Test Conditions: Repeat of Test # 7, Except No Wind, Hose Lines Deployed at 35 Seconds after Flush Deck
Control Time: 70 Seconds
Extinguishment Time: 95 Seconds
Application Rate (first 35 seconds): 0.04 GPM/SqFt
Application Rate (after 35 seconds): 0.056 GPM/SqFt
Application Density: 0.089 Gals/SqFt

Test # 9
Test Conditions: Repeat of Test # 7, Except 30 Knots Wind, Hose Lines Deployed at 39 Seconds after Flush Deck
Control Time: 30 Seconds
Extinguishment: 70 Seconds
Application Rate (first 39 seconds): 0.04 GPM/SqFt
Application Rate (after 39 seconds): 0.056 GPM/SqFt
Application Density: 0.065 Gals/SqFt

NWC China Lake, Phase III, February 1972(4)

Test # 5
Test Conditions: 7500 Sg Ft Pool Fire Area, 2500 Gals Jp-5, Aircraft Mock-Up with Running Fuel, 5 Aircraft Fuselages, 150 Gal AvGas Dump Tank, 3 Magnesium Flares in Center of Fire, No Wind

AFFF Flush Deck @ .04 GPM/SqFt, No Hose lines, Dump Tank Dumped @ 48 Seconds
Control Time: 60 Seconds
Extinguishment Time: 100 Seconds
Application Rate: 0.04 GPM/SqFt
Application Density: 0.067 Gals/SqFt

Test # 11
Test Conditions: Same as Test # 5, Except AFFF Flush Deck @ .06 GPM/SqFt, Dump Tank Dumped @ 35 Seconds
Control Time: 40 Seconds
Extinguishment Time: 80 Seconds
Application Rate: 0.06 GPM/SqFt
Application Density: 0.08 Gals/SqFt

Test # 17
Test Conditions: Same as Test # 5, Except AvGas, 15 Knots Wind, No AFFF Flush Deck, AFFF hose Lines (2 x 125 GPM), Dump Tank @ 40 Seconds
Control Time; 60 Seconds
Extinguishment Time: 100 Seconds
Application Rate: 0.033 GPM/SqFt
Application Density: 0.055 Gals/SqFt

Test # 18
Test Condition: Same as Test # 17, Except 25 Knots Wind, AFFF Hose Lines Reduced to 60 GPM Each
Control Time: 70 Seconds
Extinguishment Time: 120 seconds
Application Rate: 0.016 GPM/SqFt
Application Density: 0.032 Gals/SqFt

NWC China Lake, October 1982-Novenber 1983(5)

Test # A-1R
Test Conditions: 4000 Sq Ft Pool Fire, 1500 Gals JP-5, 30 Knots Wind, Aircraft Mock-Up in Center
AFFF Flush Deck @ .06 GPM/SgFt
Control Time: 24 Seconds

Extinguishment Time: 45 Seconds
Application Rate: 0.06 GPM/SqFt
Application Density: 0.045 Gals/SqFt

Test # A-6
Test Conditions: Repeat of Test # A-1R , Except 15 Knots Wind
Control Time: 30 Seconds
Extinguishment Time: 70 Seconds
Application Rate: 0.06 GPM/SqFt
Application Density: 0.07 Gals/SqFt

Test # A-30
Test Conditions: Same as Test # A-1R, Except Debris Pile (50 GPM Cascading Fuel) Added Within Pool Fire
Control Time: 40 Seconds
Extinguishment Time: 70 Seconds
Application Rate: 0.06 GPM/SqFt
Application Density: 0.07 Gals/SqFt
Note: AFFF Hose Line Used For Complete Extinguishment of Running Fuel in Debris Pile

Test # A-39
Test Conditions: Same as Test # A-30, Except Tire Pile Substituted For debris pile
Control Time: 24 Seconds
Extinguishment Time: 35 Seconds
Application Rate: 0.06 GPM/SqFt
Application Density: 0.035 Gals/SqFt
Note: AFFF Hose Line Used to Complete Extinguishment of Tires

Test # A-12R
Test Conditions: 4000 Sg Ft Pool Fire, 1500 gals JP-5, 30 Knots Wind, Aircraft Mock-Up in Center
AFFF Hose Line, 1 ½ Inch, 1 x 125 GPM
Control Time: 27 Seconds
Extinguishment Time: 42 Seconds
Application Rate: 0.031 GPM/SqFt
Application Density: 0.022 Gals/SqFt

Test # A-9R
Test Conditions: Same As Test # A-12 R, Except Used Two AFFF Hose Lines (one 1 ½ Inch @ 125 GPM, and One 2 ½ Inch @ 250 GPM)
Control Time: 13 Seconds
Extinguishment Time: 19 Seconds
Application Rate: 0.093 GPM/SqFt
Application Density: 0.029 Gals/SqFt

NRL Chesapeake Beach, 1984(6)

Test # 16
Test Conditions: Debris Pile With 50 GPM Cascading Fuel Source, 30 Knots Wind, AFFF Hose Line (1 ½ Inch @ 100 GPM) 50 Feet Upwind, Hose Line Stationary
Extinguishment Time: 60 Sec
Note - Control Time, Application Rate/Density Not Applicable For Debris Pile Tests Without A Pool Fire

Test # 17
Test Conditions: Same As Test # 16, Except 2 ½ Inch AFFF Hose Line @ 200 GPM In Place Of 1 ½ Inch Hose
Extinguishment Time: 60 Seconds

NWC China Lake, December 1984 – February 1985(7)

Test # 7A
Test Conditions: 4000 Sq Ft Pool Fire, 1500 Gals JP-5, Aircraft Mock-Up In Center, 30 Knots Wind
AFFF Flush Deck @ 0.06 GPM/SqFt
Control Time: 30 Seconds
Extinguishment Time: 50 Seconds
Application Rate: 0.06 GPM/SqFt
Application Density: 0.05 GALS/SqFt

Test # 6A
Test Conditions: Same As Test # 7A, Except 15 Knots Wind
Control Time: 40 Seconds
Extinguishment Time: 75 Seconds
Application Rate: 0.06 GPM/SqFt
Application Density: 0.075 Gals/SqFt

Test # 10
Test Conditions: Same As Test 7A, Except No Wind
Control Time: 60 Seconds
Extinguishment Time: 90 Seconds
Application Rate: 0.06 GPM/SqFt
Application Density: 0.09 Gals/SqFt

NRL Chesapeake Beach, 1991(8)

Test # (Total Of Seven Tests, No Test Numbers)
Test Conditions: Debris Pile With 50 GPM Cascading Fuel Fire, Wind: 0, 15, 30 Knots
Fuel: JP-5 and 50/50 Mixtures JP-5/JP-8
AFFF Hose Line (1 ½ Inch @ 125 GPM)
Debris Pile Extinguishment Time: Less Than 60 Seconds All 7 Tests

ANALYSIS OF THE DATA

AFFF Flush Deck

The specific test data applicable to the performance of AFFF flush deck nozzles is summarized in Table 1.

Table 1 - Summary of AFFF Flush Deck Tests

Data Source (Ref) #	Appl Rate	Wind Speed (Knots)	Pool Size (SqFt)	Control Time (Secs)	Ext Time (Secs)	Appl Density	Debris Pile (Y/N)	Mock Up (Y/N)	Notes
(2)14	0.06	30	2200	20	30	0.03	N	Y	
(2)21	0.06	30	2200	25	40	0.04	N	Y	AFFF ½ Strength
(5)A-1R	0.06	30	4000	24	45	0.045	N	Y	
(5)A-30	0.06	30	4000	40	70	0.07	Y	Y	
(5)A-39	0.06	30	4000	24	35	0.035	Tires	Y	
(7)7A	0.06	30	4000	30	50	0.05	N	Y	
(5)A-6	0.06	15	4000	30	70	0.07	N	Y	
(7)6A	0.06	15	4000	40	75	0.075	N	Y	
(4)11	0.06	0	7500	40	80	0.08	N	Y	5 A/C, Dump Tank, Flares
(7)10	0.06	0	4000	60	90	0.09	N	Y	
(3)2	0.04	30	7500	20	28	0.019	N	Y	Bare Spots In Fuel
(3)4	0.04	30	7500	30	38	0.025	N	Y	
(3)1	0.04	0	7500	27	35	0.023	N	N	Clear Deck, Wind 1-2 Kts
(4)5	0.04	0	7500	60	100	0.067	N	Y	5 A/C, Dump Tank, Flares
		Overall Average		34	56	0.051			

The data in Table 1 is grouped by application rate (0.06 or 0.04 GPM/SqFt) and wind speed (30, 15, 0 knots). As can be seen, data for AFFF flush deck nozzle performance exists on pool fires ranging from 2200 to 7500 SqFt. Several significant conclusions can be drawn from the Table:

1. As explained previously, performance of flush deck nozzles is better at higher wind speeds. Control time was as short as 20 seconds for 30 knots and as long as 60 seconds for 0 knots.

2. Performance decreases with the degree of clutter on the deck. Tests 1(3) and 5(5) were essentially identical except 1(3) was run with a clear deck. Control time for the cluttered deck was over twice as long and extinguishment time was nearly three times as long as for the clear deck scenario.

3. Comparing tests 11(4) and 5(4) shows the advantage of a higher flush deck application rate. Control and extinguishment was 20 seconds faster with the higher application rate.

4. In spite of the wide ranging test conditions (varying pool size, wind speed, degree of clutter, and application rate) fire control time with the AFFF flush deck nozzles was never greater than 60 seconds, extinguishment time was never greater than 100 seconds, and application density for extinguishment never exceeded 0.09 Gals/SqFt.

5. At the bottom of the table is the arithmetic average of performance for all 14 tests:

Control Time = 34 Seconds
Extinguishment Time = 56 Seconds
Application Density = 0.051 Gals/SqFt

This average tends to normalize the data by factoring out the lower performance due to lower application rate, zero wind and deck clutter. It is reasonable to conclude that the average numbers would be applicable to the helo decks in question, since they are all designed with a flush deck application rate of 0.06 GPM/Sq Ft, wind across the landing line is common practice during helo operations, and clutter representative of a stacked aircraft carrier flight deck would not be found on a helo deck during flight quarters.

AFFF Hose Lines

The specific test data applicable to the performance of AFFF hose lines is summarized in Table 2.

Table 2 – Summary of AFFF Hose Line Tests

Data Source (Ref) #	Flow Rate(s) (GPM)	Hose Size (inch)	Wind Speed (Kts)	Debris Pile (Y/N)	Pool Size (SqFt)	Control Time (Secs)	Ext Time (Secs)	Appl Rate	Appl Dens	Notes
(1) 23	1 x 60	1 ½	30	N	3525	46	66	0.017	0.019	Clear Deck
(5)A-12R	1x125	1 ½	30	N	4000	27	42	0.031	0.022	Mock Up
(1) 22	1 x 60	1 ½	0	N	3525	32	41	0.017	0.012	Clear Deck
(1) 29	1 x 60	1 ½	0	N	3525	38	48	0.017	0.014	Clear Deck
(4) 18	2 x 60	1 ½	30	N	7500	70	120	0.016	0.032	5 A/C,Dump Tank, Flares,Mock Up
(5)A-9R	1x125 1x250	1 ½ 2 ½	30	N	4000	13	19	0.093	0.029	
(3) 6	2 x 60	1 ½	30	N	7500	33	45	0.016	0.012	Mock Up
(4) 17	2x125	1 ½	15	N	7500	60	100	0.033	0.055	5 A/C,Dump Tank, Flares,Mock Up
(6) 16	1x100	1 ½	30	Y			60			50 Ft Upwind
(6) 17	1x200	2 ½	30	Y			60			50 Ft Upwind
(8)	1x125	1 ½	0, 15, & 30	Y			<60			Total of 7 Tests Vs Debris Pile

The data in Table 2 is grouped by number of hose lines deployed (single vs two hose attack) and a separate grouping for debris pile tests without pool fires. The following points are salient:

1. The debris pile, with internal running fuel fire, was always extinguished within 60 seconds, even for flows as low as 100 GPM.

2. Test 17(4) shows the ability of two hose lines flowing the same as hose lines on the helo deck(125GPM). Even for a 7500 SqFt cluttered flight deck fire, the hose lines without flush deck obtained control in 60 seconds with 15 knots of wind.

3. Test A-12R(5) was conducted with a single hose flowing the same as a helo deck hose (125 GPM). The fire size was 4000 SqFt, which is considerably larger than the helo landing area on the combatant ships in question. Helo landing areas as reported in Ship Aviation Facilities Manual (NAEC-ENG-7576) are as follows:

Ship	Length	Width	Area
CG-47	54' 6"	41' 7"	2300 SqFt
FFG-7	53' 6"	38'	2000 SqFt
DD-963	52' 7"	40" 11"	2200 SqFt
DDG-51	48' 10"	47'	2300 SqFt

Additionally, a mock-up comparable to the fuselage length of the standard LAMPS helo, the SH-60, was placed in the center of the pool fire (mock-up length = 36 feet, SH-60 fuselage length = 50 feet). Wind speed was 30 knots, same as the normal wind during helo ops. Control time was 27 seconds and total extinguishment time was 42 seconds. The results of these tests are considered to be representative of the expected performance of a single AFFF hose line on the helo deck of any of the four ships listed above.

Combined AFFF Flush Deck and Hose Lines

Table 3 summarizes the specific test data for extinguishment evolutions involving the combined application of AFFF flush deck nozzles and hose lines. Only three applicable tests were identified in the cited references. All three tests consisted of fire sizes of 7500 SqFt, three different wind speeds, cluttered deck and running fuel. Two hose lines having a combined flow rate about the same as a single hose on a helo deck were used (2 x 60 = 120 GPM). However, the flush deck had only a .04 application rate.

Table 3 – Test Summary
Combined AFFF Flush Deck & Hose Lines

Data Source (Ref) #	FD Appl Rate	Hose Lines	Time HL In (secs)	Wind Speed (kts)	Pool Size (SqFt)	Cont Time (Secs)	Ext Time (Secs)	FD/HL Appl Rate	FD/HL Appl Dens	Notes
(3) 9	0.04	2 x 60	39	30	7500	30	70	0.056	0.065	5 A/C,MockUP Fuel Drum
(3) 7	0.04	2 x 60	37	15	7500	37	70	0.056	0.065	5 A/C,MockUp Fuel Drum
(3) 8	0.04	2 x 60	35	0	7500	70	95	0.056	0.089	5 A/C.MockUp Fuel Drum

The following can be deduced from the Table:

1. Control times were better with the highest wind speed due to the contribution of the flush deck prior to the hose line application.

2. Except for the zero wind test, the flush deck controlled the fire prior to the hose lines being deployed. This might be a comparable scenario to a fire on a helo deck where the Helo Control Officer immediately activates the flush deck while the hose teams are pulling hoses and advancing.

3. A comparison between test 7(3) on Table 3 and test 17(4) on Table 2 illustrates the contribution of the flush deck system. For the same fires (7500 SqFt, cluttered deck, 15 knots), combining the flush deck with the hose lines reduced the control time from 60 seconds to 37 seconds and reduced the total extinguishment time from 100 seconds to 70 seconds.

4. A similar comparison between test 9(3) on Table 3 with test 18(4) on Table 2 also illustrates the contribution of the flush deck, and shows how even a highly cluttered deck with 5 aircraft involved can be controlled in 30 seconds and totally extinguished in 70 seconds using a combined flush deck and hose line attack.

OVERALL CONCLUSION

The AFFF systems serving the helo decks on surface combatants are designed for rapid control and extinguishment of JP-5 pool fires. Based on the available data, either the flush deck system at an application rate of 0.06 GPM/SqFt or a single hose line @ 125 GPM would be expected to perform as follows against a pool fire engulfing the landing area of the CG-47, DD-963, FFG-7, or DDG-51:

Fire Control Time: 30 Seconds

Fire Extinguishment Time: 60 Seconds

This estimate assumes a typical wind of 15-30 knots in a general fore-to-aft direction. Extreme wind conditions outside the normal range could add 15-30 seconds to the above times. This estimate also assumes that the AFFF systems are adequately maintained and operationally ready and that flight quarters personnel are properly trained.

A simultaneous attack by both systems could facilitate even more rapid fire control.

RECOMMENDATIONS

The historical test data in this report documents the performance capability of the AFFF systems serving the helicopter decks on U.S. Navy ships. This performance capability shows that the AFFF flush deck system and a single AFFF hoseline are capable of quickly extinguishing a fire resulting from an aircraft crash incident. In order to obtain maximum benefit from the AFFF flush deck system, the doctrine stipulated in chapter 9 of the Firefighting NATOPS Manual (NAVAIR

00-80R-14) should mandate immediate activation of the flush deck system for any pool fire on the flight deck. The test results also indicate that there should be opportunity to reduce the number of AFFF hose teams required for flight deck operations. It is therefore recommended that the current flight quarters requirement for 3 hose teams (including the Background Assistance Detail) [9], be changed to 2 hose teams comprised of an assigned hose team backed up by a second hose team of flight deck support personnel (chock and chain crew).

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